Literature Review: Accuracy and Validity of the Apple Watch

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### Introduction

Smart watches have been integrated into our everyday lives as a way to not only communicate with others but to also learn more about ourselves. What used to be such a crazy and bizarre concept to grasp suddenly became an essential to not only stay connected with others but to also begin taking care of ourselves through daily reminders such as drinking water, standing up and walking, and breathing. The purpose of the smart watch originally was to be a new form of convenient technology for busy people -- essentially, it is a phone in watch form. However, smart watches enabled individuals to begin caring about their personal health and their doctor is not their first resort anymore. Individuals finally have health goals that can be specific to them instead of just saying “I want to be healthier”. Smart watches have changed the way one perceives health; suddenly, it has become realistic to be healthier through the use of smartwatches.

Due to their features that can measure heart rate, energy expenditure, and volumetric changes in blood in peripheral circulation, smartwatches enable the user to become more involved in their health. There are many studies done where they compare the functionality of multiple smartwatches against an ECG to determine the accuracy and whether or not these smartwatches can be used to detect atrial fibrillation. Although there are many trials and studies done, more trials and studies must be done to further solidify the accuracy and validity of these devices targeting people with specific health conditions.

There have been conversations about using smart watches beyond personal use and in clinical trials but, there have been many questions and doubts about the accuracy and validity of smart watches. However, because the health monitoring applications on smart watches are so new, the parameters of the validity and accuracy of these devices are not yet set. To discover what research has been done to determine the validity of Apple Watches, a literature review has been completed on the research of validity and accuracy of the Apple Watch on heart rates done in the past 10 years.

### Accuracy of Apple Watches

It came as a surprise to many researchers when Apple Watches had a high accuracy on measuring heart rates. Many of the trials that have been done to determine the accuracy of Apple Watches were done through comparing the Apple watch's competitors to the control The control is a reliable machine that determines the heart rate precisely. It was seen in almost all of the research that the Apple Watch has the highest accuracy. However, the accuracy of heart rate fluctuates based on the intensity of the exercise completed. In some articles, such as the “Validity and Reliability of the Apple Watch for Measuring Heart Rate During Exercise”, 21 males completed a treadmill exercise with an Apple Watch and a Polar S810i monitor which had different levels of intensity, along with some time to rest after the intense exercise. Through all of this, the heart rate was constantly monitored on both wrists with the two different wearable devices. The results of the trial allowed the authors to conclude that the more intense a physical activity is, the less accurate the heart rate reading becomes .

In most of the studies, there was no significant data showing that one device performed better than the other. They all performed relatively the same. The apple watch performed better than most smart watches, but not significantly better. For example, in the article “Heart Rate Measures from the Apple Watch, Fitbit Charge HR 2, and electrocardiogram across different exercise intensities”, the apple watch and fitbit were compared against an electrocardiogram (ECG) to determine the relative error rates (RER) when measuring heart rate of the two devices. The apple watch showed a lower RER rate during all exercise intensities of 2.4-5.1% whereas the fitbit had a RER of 3.9-13.5%. This article also supports the argument that as the intensity of physical exercise increases, the accuracy of heart rate monitoring decreases. Although the error rates were not significantly different, the apple watch performed better results than the fitbit charge 2.

### Longitudinal VS Cross Sectional Studies

The research on Apple Watches is very new and only has less than a decade worth of data. The Apple Watch itself was introduced in September 2014 and already has 4 different generations. Despite this, there are many different kinds of studies being done, such as longitudinal and cross sectional studies. Longitudinal studies are observations done on the same subject or group of people over a period of time. This is important in research, specifically with a concept as new as the accuracy of Smart Watches on human heart rate. This set of rare data provides us with an idea of whether the accuracy has improved based on the different upgrades of Apple Watches. In addition, this information can also give researchers an idea on creating different trials to solve different problems.

Cross sectional studies are observational studies that analyze data from a population at a specific point in time. This data is also important because it can identify conflict of interests and allows the data to be seen in one observation. Analyzing one observation allows us to observe everything that could have happened in that one happening. Other studies that were done also include comparison studies and validation studies. These different types of studies are important for researchers to be able to gain different perspectives of one concept.

### Validity of Apple Watches in Clinical Trial

The Apple Watch tends to have a higher percent of accuracy of heart rate, but was not recommended for clinical use. Although it had a higher percentage of accuracy compared to its competitor, it is not as accurate as the machines being used as the control in these trials. These machines include chest strap heart rate monitors and EKG monitors. The accuracy of the Apple Watches fluctuated and was never always accurate depending on what the owner of the watch was doing. This can be seen in “Validity of Wearable Activity Monitors during Cycling and Resistance Exercise”, where to determine the validity of heart rate, 50 subjects completed separate trials of cycling and 3 sets of 4 resistance exercises in 10-repeititon-maximum load. There was a high accuracy and validity when the patient was at the highest intensity of a workout, but the accuracy was different between men and women. The Apple Watch is still too new to rely on in terms of clinical information and trial, and could create a lot of conflict of interests. In all research, there was a unison agreement that it should be cautioned to use Apple Watches for clinical purposes.

In another study done among children, there was no significant systematic bias between gender, weight, height, and BMI percentile, however in conclusion of the results, it is unclear whether or not the apple watch 3 is a valid wearable device for measuring energy expenditure in children. This is shown in the article, “Validation of the Apple Watch for Estimating Moderate-to-Vigorous Physical Activity Energy Expenditure in School-Aged Children”. Twenty elementary school children had worn an apple watch 3 along with a K5 indirect calorimetry and GT3X+ to monitor physical activity. The moderate-to-vigorous physical activity (MVPA) in children living in free-living conditions could not be accurately estimated, therefore the accuracy and validity of it is not supported. However, when promoting MVPA and an active lifestyle in children, the devices can be used to measure physical activity information.

### Conclusion

There is a lot of potential within the Smart Watch to not only be better at easing daily tasks for everyday life, but to also provide us with more information on our health beyond our steps and calories. Measuring heart rate is only the beginning, and can help individuals measure other health concerns and create more preventative measures to allow accessible healthcare. Smart watches are still going through upgrades and improvements to ensure more accurate results regarding health monitoring. However, if these studies were more targeted towards specific people with specific health conditions and larger in scale, they would definitely be beneficial in becoming a valid health mobile device used for measuring and recording health status’. Judging from the articles, smartwatches have a long way to go to confirm validity and accuracy, but out of the smartwatches, the apple watch seems to be the most accurate with the least error rates. The differences of error rates between smartwatches are not significantly bigger than one another, however it is a great accomplishment that the apple watch is constantly measuring more accurately than other smartwatches. Although the Apple Watch has room for a lot of growth and improvements, the current state it is in right now allows individuals to get an idea of what their health may look like and what they can do to improve it.

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